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The "Plate" model for the Iceland melting anomaly

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The recent proposal that Iceland is not underlain by a deep mantle plume, but that excess magmatism there results from shallow upper mantle structures and processes, has its roots in a seismic tomography experiment done in the early 21st century. That experiment suggested that the seismic anomaly beneath Iceland was confined to the upper mantle, a result that was immediately and repeatedly confirmed and reconfirmed by other, indepenent seismic experiments. Morgan-type mantle plumes, which are required to rise by virtue of thermal buoyancy, and whose roots are required be fixed relative to one another, must arise from a thermal boundary layer deep in the mantle. The seismic results essentially rule out such a structure beneath Iceland. So-called "upper-mantle plumes" cannot be Morgan-type plumes because the base of the upper mantle is not a thermal boundary layer. It is a mineralogical phase change and there is no reason why thermal plumes should form at it. Postulated uprising convection limbs in the upper mantle should not be called plumes since they do not fit Morgan's criteria, nor those of recent updates to his model (http://www.mantleplumes.org/Plumes.html).

The question then arises as to what causes the phenomenon we view as the "Iceland melting anomaly". The following primary observations from the region may be highlighted:

- "LIP" magmatism in the region occurred in two phases, a) accompanying opening of the north Atlantic ocean at ~ 54 Ma, and forming the volcanic margins, and b) centred on the mid-Atlantic ridge at the latitude of Iceland, during the last ~ 30 Ma;
- Widespread uplift of the north-Atlantic margins occurred, largely coeval with ocean opening at ~ 54 Ma;
- Magmatism has essentially always been centred on the spreading ridge;
- Of a suite of ~ 15 methodologically diverse studies of the temperature of the mantle beneath Iceland, none require high temperatures. All either require, or are consistent with, a temperature anomaly in the range 50 – 100˚C;
- The region is tectonically complex. There is no time-progressive volcanic chain. Instead the region is a diffuse spreading plate boundary with a complex history of microplate creation and abandonment and ridge migrations in both easterly and westerly directions. The strike of the mid-Atlantic ridge changes radically at the latitude of Iceland. The region appears to be in tectonic disequilibrium for a reason that we do not understand;
- The seismic anomaly beneath Iceland is of the order of 100s of km broad. It does not extend down beneath the mantle transition zone, and it is elongated parallel to the mid-Atlantic ridge at depth.

None of these observations are naturally explained by the plume model and thus a new model has been developed to explain the excessive magmatism. The volcanism occurs where the new mid-Atlantic ridge crossed the western frontal thrust fault of the Caledonian suture. To the south, the new ridge split the Laurentian craton and to the north it ran along the

Caledonian suture. Many Icelandic lavas are of the ocean island basalt (OIB) type, generally agreed to indicate a component of recycled near-surface material. Such material is fusible – it produces larger volumes of melt than mantle peridotite at the same temperature. The shallow based model suggests that the excess magmatism at Iceland arises from the entrainment of fusible, recycled material, perhaps Caledonian slabs, in otherwise relatively normal mid-ocean-ridge upwelling.

This talk will present technical details of the shallow-based "plate" model for melting anomalies (http://www.mantleplumes.org/PTProcesses.html). It will compliment the less technical talk I shall give for the general public in the Museum of Luxembourg on the evening of 12th November.